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BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C.

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Federal Communications Commission
Office of the Secretary

In the Matter of	)
	)
Requests for Waiver of Section 22.913 of the Commission's Rules to Permit AT&T to Use a PSD Measurement in the Cellular Bands of a Limited Number of Markets	)

PETITION FOR WAIVER
FOR LICENSES IN KENTUCKY AND TENNESSEE

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AT&T Services, Inc., on behalf of its subsidiaries (collectively, "AT&T"), pursuant to Federal Communications Commission ("Commission") Rule Section 1.925, requests a waiver of Section 22.913 of the Commission's rules for Cellular licenses in Kentucky and Tennessee.[1]

I. BACKGROUND

Commission Rule Section 22.913 sets the effective radiated power ("ERP") limits for Cellular base stations, which has generally been applied *per channel*. On February 29, 2012, AT&T filed a Petition for Rulemaking ("Petition") proposing revisions to Section 22.913 that would authorize the use of a power spectral density ("PSD") model to set an alternative base station ERP limit of 250 Watts per megahertz ("W/MHz") in non-rural areas and 500 W/MHz in rural areas.[2] In its Petition, AT&T explained that setting Cellular base station ERP using a PSD model would eliminate unintended penalties on the deployment of advanced digital broadband

[1] 47 C.F.R. § 22.913.

[2] *In the Matter of Amendment of the Commission's Rules Governing Radiated Power Limits in the Cellular Radio Service Frequency Bands,* Petition for Expedited Rulemaking and Request for Waiver, RM-11660, DA-12-701 (filed Feb. 29, 2012) ("Petition").

modulation schemes in the Cellular bands and allow Cellular licensees to more efficiently deploy Cellular broadband service.

On November 10, 2014, the Commission released a Further Notice of Proposed Rulemaking ("Further Notice") that proposed to allow Cellular licensees to calculate ERP using a PSD model.[3] Pending resolution of this rulemaking, AT&T is seeking license-specific waivers, as needed, of the ERP limits by channel in favor of using a PSD measurement. These waivers will allow AT&T to more quickly and efficiently deploy high-speed wireless broadband services over Cellular spectrum. In this request, AT&T seeks a waiver of Section 22.913 to allow for base station operations at 250 W/MHz in non-rural areas and 500 W/MHz in rural areas in the following markets:[4]

State	License	CMA	Block
KY/TN	KNKA576	209	B
KY	KNKA672	293	A
KY	KNKN674	444	A
KY	KNKN666	447	A
KY	KNKN841	452	A
KY	KNKN861	451	A
KY	KNKN964	448	B
KY	KNKN965	448	B
KY	KNKN673	453	A

Commission Chairman Wheeler has stated:

> Our role is to harness the power of modern communications to produce social and economic benefits. This we can accomplish in two ways. First, by removing obstacles to progress, whether the obstacles are unnecessary or counterproductive regulations or private arrangements that restrict economic, intellectual, and cultural advancement. And

[3] Amendment of Parts 1 and 22 of the Commission's Rules with Regard to the Cellular Service, Including Changes in Licensing of Unserved Area, *et al,* WT Docket No. 12-40, RM-11510, RM-11660, 29 FCC Rcd 14100, 14135-44 (2014) ("*Further Notice*").

[4] The main counties comprising the Cellular Geographic Service Area (CGSA) for each license are identified in Appendix A.

> second by assuring the availability of the economic inputs we manage which are essential to modern networks. By far the most important of these inputs is spectrum.[5]

The Commission can fulfill this role in both ways by waiving and, ultimately, modifying Section 22.913 to allow Cellular licensees to set base station power limits using PSD. Setting base station ERP using a PSD measurement will allow AT&T to more efficiently deploy LTE over the same spectrum resources and thus, more effectively meet the data demands of its customers. Further, as explained below, the PSD limits will not increase the risk of interference to public safety entities. Nevertheless, AT&T will continue to adhere to the Commission's Part 22 and companion Part 90 rules intended to address interference with public safety operations. For all these reasons, as explained more fully below, grant of a waiver is in the public interest and meets all qualifications of Rule Section 1.925.

II. DISCUSSION

Under Section 1.925(b)(3) of its rules, the Commission may grant a request for waiver if the applicant demonstrates that: (i) the underlying purpose of the rule for which the waiver is sought would not be served or would be frustrated by application of the rule, and that the grant of the requested waiver would be in the public interest; or (ii) in view of unique or unusual factual circumstances, application of the rule would be inequitable, unduly burdensome, or contrary to the public interest, or the applicant has no reasonable alternative.[6] As described in this waiver request, permitting AT&T to use a PSD model to set base station ERP in the designated Kentucky and Tennessee markets at 250 W/MHz in non-rural areas and 500 W/MHz in rural

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[5] Prepared remarks of FCC Chairman Tom Wheeler, "Wireless Spectrum and the Future of Technology Innovation" Forum – Brookings Institution, March 24, 2014, http://www.fcc.gov/document/chairman-wheeler-remarks-brookings-institution.

[6] *See,* 47 C.F.R. §1.925; *WAIT Radio v. FCC,* 418 F.2d 1153 (D.C. Cir. 1969).

areas is in the public interest because it will foster the deployment of broadband LTE in the Cellular service and will not increase the potential for interference.

A. Grant of the Waiver is in the Public Interest Because it Promotes Broadband LTE Deployment in the Cellular Bands.

Grant of this waiver is in the public interest by removing disparities between radio services that limit Cellular carriers' ability to deploy the most efficient and advanced modulation techniques[7] and by promoting the deployment of mobile broadband services, including in rural areas. Wireless providers have experienced extraordinary increases in the volume of data generated by consumers and businesses as a result of the popularity and ubiquity of smartphones and other data-enabled devices. Having pioneered devices like the iPhone and aggressively promoted the latest technologies and applications, AT&T has borne the brunt of a substantial amount of this newly generated traffic. Over the last eight years, data traffic over AT&T's wireless network has increased an astounding 100,000 percent.[8] To help meet that demand, AT&T has invested nearly $140 billion in capital, spectrum, and other assets over the last six years to build and enhance its networks, including increasing its LTE build-out.[9]

Notwithstanding that massive investment, AT&T remains critically constrained by access to spectrum, while data usage continues to soar. To maintain high-quality service for its customers, AT&T must continue to rapidly and aggressively roll-out more efficient LTE services over all of its spectrum bands, notably 850 MHz Cellular. Deploying LTE over existing 850

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[7] *See,* Petition at 9–12.

[8] AT&T Inc. 2014 Annual Report at 2, http://www.att.com/Investor/ATT_Annual/2014/downloads/att_ar2014_annualreport.pdf.

[9] *Id.* at 6.

MHz infrastructure and frequencies would provide significant operational and spectrum efficiencies. Unfortunately, as the Commission has observed:

> The . . . current [base station power] limits apply to each emission or channel, so that a licensee using narrow emissions can transmit more total power per MHz than a licensee using wideband emissions. For example under the current rules, a Cellular licensee using a 5 MHz LTE emission in a non-rural area would be limited to 500 W in those 5 MHz (100 W/MHz), while a licensee in the same 5 MHz could deploy four CDMA channels with an aggregate power of 2000 W ERP (400 W/MHz), or 12 GSM channels with an aggregate power of 6000 W ERP (1200 W/MHz).[10]

This penalty on wideband emissions dilutes and potentially precludes deployment of the most up-to-date, efficient wideband technologies to the broadest population.

The impact of these inefficiencies is notable when comparing narrowband GSM coverage versus broadband UMTS and LTE coverage under current base station power rules. Compared to its GSM coverage, AT&T's LTE and UMTS coverage contracts when deployed under current base station power rules. For example, at the same power per transmitter, coverage with UMTS is less than with GSM and, more telling, coverage with LTE over a 10 MHz channel is less than with LTE over a 5 MHz channel. Reduced coverage is especially disadvantageous in rural counties, such as the majority of counties covered by AT&T's waiver request, where base stations are more widely dispersed or where a single base station may be deployed. Allowing AT&T to operate at the PSD levels of 250 W/MHz in non-rural areas and 500 W/MHz in rural areas will allow AT&T to continue to provide consumers with the coverage they have come to expect and to recognize the spectral efficiencies inherent in LTE.

To this end, it is in the public interest to authorize AT&T to use the PSD model to calculate Cellular base station ERP at 250 W/MHz in non-rural areas and 500 W/MHz in rural areas in the above-referenced Kentucky and Tennessee markets pending resolution of the Further

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[10] *Further Notice* at 14138-39.

Notice. This conclusion is supported by the Commission's grant of similar waiver requests to operate using the PSD model in certain Florida, Vermont, and Missouri markets.[11] In those matters, the Commission examined the data provided by AT&T and concluded that allowing the use of the PSD model "better serves the public interest than strict application of the current Cellular radiated power rule."[12] The same rationale applies to the Kentucky and Tennessee markets listed above, warranting grant of the waiver.

B. Grant of the Waiver Would Not Increase the Interference Risk in Adjacent Bands.

One of the Commission's core missions is to manage spectrum effectively and ensure that licensees do not interfere with each other.[13] To reduce the potential for interference with licensees operating in adjacent bands, the Commission establishes power limits within each wireless service, such as Section 22.913. Grant of the waiver requested herein would not undermine the purpose of Section 22.913, as the interference environment using a PSD calculation at the ERP limits proposed by AT&T remains relatively the same as (or better than) the current ERP measure.

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[11] Interim Waiver of 47 C.F.R. § 22.913 to Permit the Use of a Power Spectral Density Model for Certain Cellular Service Operations in Three Florida Markets, WT Docket No. 13-202, 29 FCC Rcd 11638 (2014) ("Florida Waiver"); Interim Waiver of 47 C.F.R. § 22.913 to Permit the Use of a Power Spectral Density Model for Certain Cellular Service Operations for Cellular Market 248 – Burlington, VT, WT Docket No. 14-10, 29 FCC Rcd 11632 (2014) ("Vermont Waiver"); Interim Waiver of 47 C.F.R. § 22.913 to Permit the Use of a Power Spectral Density Model for Certain Cellular Service Operations in Four Missouri Markets, WT Docket No. 15-86 (2015) ("Missouri Waiver").

[12] Florida Waiver at 11643; Vermont Waiver at 11636; Missouri Waiver at ¶14.

[13] 47 U.S.C. §302.

1. Use of PSD Keeps the Status Quo with Public Safety.

Attached hereto as Appendices B and C are studies prepared by AT&T demonstrating that the use of a PSD model for calculating Cellular base station ERP at 250 W/MHz in non-rural areas and 500 W/MHz in rural areas will not increase the potential for interference with public safety systems in any of the subject markets.[14] In this study, AT&T compared the potential interference effects of various wireless network arrangements on public safety receivers. The test cases in the study represent AT&T's past, present, and future wireless networks—various configurations of GSM, UMTS and/or LTE (with 2 x 2 MIMO[15]) systems in the Cellular band. The study addressed three near/far interference mechanisms common in the public safety interference environment – intermodulation, out-of-band emissions ("OOBE"), and receiver overload. The benchmarks used to measure significant interference were a rise in the receiver's noise floor greater than 1 dB for intermodulation and OOBE and a received interference level higher than the overload limit of the affected receiver for receiver overload. Public safety receiver performance was based upon current models with relatively wide open front-end filtering encompassing the range from 851-869 MHz, with receiver bandwidths of 12.5 and 25 KHz.

AT&T's study confirms the absence of any significant effects upon public safety services in the Kentucky and Tennessee markets arising from operating Cellular base stations at ERP limits based upon a PSD model—finding, for example, that AT&T's future LTE deployments in

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[14] The findings are identical to those in the study attached as Appendix A to AT&T's Petition.

[15] To increase spectral efficiency and throughput of a radio link, multiple transmitters using the same frequency and multiple antennas or multiple elements of the same antenna are used to create multiple distinct spatial channels between the transmitters and antenna(s). With the aid of a multipath environment and signal processing, multiple channels are created using the same frequency at each transmitter. This technology is referred to as MIMO (Multiple Input Multiple Output).

the Cellular bands under a PSD limit would maintain the *status quo* with public safety services. With respect to intermodulation interference, at the three distances from the Cellular base station site (40 meters, 200 meters, and 1000 meters) for all migration paths, the noise floor rise for LTE deployments with MIMO and PSD rules relief were significantly less than present technology deployments. For OOBE at the three distances from the Cellular base station for all migration paths, all noise floor rises were below 1 dB. This rise in the interference floor is insignificant in practice and is still well under the 1 dB degradation in the noise floor of the public safety mobile receiver. Finally, for overload interference, the study showed LTE deployments did not increase the number of possibilities of such interference above that of existing deployments.[16]

Moreover, the risk of interference from the use of PSD is further reduced by existing Commission rules, namely Cellular Rule Sections 22.970–22.973 and their companion public safety service Rule Sections 90.672–90.675.[17] The Association of Public-Safety Communications Officials-International, Inc. ("APCO") and the National Public Safety Telecommunications Council ("NPSTC") agree that these rules should be maintained.[18] Under those rules, the wireless industry established an 800 MHz Interference Notification Website with 24 hour response to public safety requests for interference mitigation.[19] Using this website and the procedures established under the Part 22 and Part 90 rules, Cellular licensees and public

[16] AT&T incorporates into this docket its *ex parte* submissions in WT Docket 12-40 dated May 15, 2015, July 10, 2015, and October 29, 2015.

[17] 47 C.F.R. §§ 22.970-22.973, 90.672-90.675.

[18] Reply Comments of The Association of Public-Safety Communications Officials-Int'l, Inc., WT Docket No. 12-40 at 3 (filed Feb. 20, 2015); The National Public Safety Telecommunications Council, WT Docket No. 12-40 at 4 (filed Feb. 20, 2015).

[19] The 800 MHz Interference Notification Website can be found at http://www.publicsafety800mhzinterference.com/CTIAWeb/index.aspx.

safety agencies have worked together for years to resolve any interference incidents that have arisen and will continue to do so. The availability of the Part 22 and Part 90 remedies will resolve any remaining concerns about interference into public safety systems arising from AT&T's use of a PSD model.[20]

2. Use of PSD Does not Increase the Risk of Interference to Adjacent CGSAs.

In its Petition, AT&T proposed ERP limits per megahertz based on existing transmit power levels at AT&T's sites, which would maintain the status quo in the RF environment vis-a-vis not only neighboring public safety systems, but also the CGSAs of neighboring Cellular licensees. Consequently, with the PSD limits proposed, AT&T's power levels into adjacent public safety areas and CGSAs would be the same as under current operations. AT&T will not inject increased signal energy into or increase the noise level in these bordering areas until it acquires any necessary approvals. The effect on neighboring and co-located systems – both public safety and Cellular services – is minimal.

Verizon Wireless, Appalachian Wireless, and Bluegrass Cellular are co-channel and/or adjacent channel Cellular licensees to at least one of the Kentucky or Tennessee licensees for which AT&T seeks a waiver. Verizon supports operating Cellular sites using the PSD measurements and has proposed PSD limits higher than proposed by AT&T.[21] Appalachian Wireless has filed no objections to AT&T's request for a rule change. Bluegrass Cellular

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[20] The Commission has noted the value of the 24-hour response to public safety currently required by Section 90.674. *Improving Spectrum Efficiency Through Flexible Channel Spacing and Bandwidth Utilization for Economic Area-based 800 MHz Specialized Mobile Radio Licensees, et al,* Report and Order, WT Docket No, 12-64, WT Docket No. 11-110, 27 FCC Rcd 6489, 6497 (2012).

[21] Reply Comments of Verizon Wireless, RM-11660, DA 12-701, at 4-6 (June 18, 2012). *See also* Comments of Verizon, WT Docket No. 12-40, RM No. 11510 at 2-3 (filed Jan. 21, 2015).

supports a rulemaking to explore setting base station power limits using a PSD model, but in response to AT&T's request for a waiver of Cellular rule 22.913, interposed generalized objections to a waiver grant to prevent harmful interference into Bluegrass CGSAs and re-measure and renegotiate 32 dBu service area boundary extension agreements, and because it is against the public interest.[22] Bluegrass Cellular's concerns are misplaced.

Even if AT&T obtains a waiver of the Cellular base station power limits, AT&T must, and will, comply with all existing Cellular rules governing power levels at the neighbors' borders and coordination of channel usage with those neighbors.[23] Hence, there is no increased risk of interference to the neighboring Cellular systems of Bluegrass Cellular or any other Cellular licensee. Just as the Commission concluded in granting AT&T's request to operate using PSD in Florida, Vermont, and Missouri, a waiver of Cellular rule Section 22.913 for the Tennessee and Kentucky licenses would be in the public interest and not frustrate the underlying purpose of the rule.[24]

C. AT&T's Planned LTE Deployment Using PSD.

AT&T and its customers in the counties for which the waiver is sought can benefit from the operational and spectrum efficiencies of LTE only over the Cellular service spectrum. Like many areas of the country, AT&T has deployed LTE over 700 MHz spectrum *in parts* of Kentucky and Tennessee, supplementing capacity as needed by deploying additional carriers in the AWS, PCS and Cellular bands. 700 MHz, which is authorized to operate using PSD at levels higher than the limits proposed in this docket, can be deployed efficiently on a cell site grid

[22] Comments of Bluegrass Cellular, Inc., RM-11660, at 3-5 (filed May 31, 2012).

[23] *See* 47 C.F.R. §22.907.

[24] Florida Waiver, 29 FCC Rcd at 11643; Vermont Waiver, 29 FCC Rcd at 11636; Missouri Waiver at ¶¶14-15.

designed for 850 MHz spectrum due to the similarity in propagation characteristics. However, AT&T currently holds no paired 700 MHz spectrum to deploy LTE in the Kentucky and Tennessee counties for which this waiver is requested.[25] While it is possible to deploy LTE using higher spectrum bands, such as AWS or PCS—AT&T, T-Mobile and other carriers have done so in many areas—it is more efficient to do so where the existing cell site grid was designed for a high-band only deployment. Increasing the density of AT&T's infrastructure to optimize a high-band only LTE network in the counties for which the waiver is requested would take many years.

AT&T seeks to deploy LTE carriers on its Cellular spectrum in the Kentucky and Tennessee markets using the proposed PSD power limits as soon as possible to optimize the LTE Cellular power levels and coverage with the UMTS Cellular coverage and LTE 700 MHz power levels and coverage AT&T has deployed elsewhere in Kentucky and Tennessee. This optimization will enhance AT&T's ability to use existing spectrum resources to meet the demand for data that continues unabated. AT&T has demonstrated that allowing the alternative PSD ERP limit maintains or improves the interference environment that the Commission found to be reasonable when it established Section 22.913. Moreover, the waiver—conditioned on the outcome of the pending rulemaking—would not undermine the deliberative process relative to adopting PSD limits for Cellular carriers more broadly.

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[25] Applications are pending for AT&T to acquire 700 MHz licenses in some counties covered by this Petition. *See* Application of AT&T Mobility Spectrum LLC, and East Kentucky Network, LLC for Consent to Assign Licenses, WT Docket No. 15-79 (filed Feb. 18, 2015); Applications of New Cingular Wireless PCS, LLC, Bluegrass Cellular, Inc., and Bluegrass Wireless LLC for Consent to Assign Licenses, WT Docket No. 15-225 (filed June 17, 2015). Even if AT&T acquires this spectrum, AT&T will be able to more efficiently deploy LTE over Cellular using PSD in the short term. LTE is already deployed over Cellular in these areas under current base station power levels and could be easily modified to use PSD, whereas deploying LTE over 700 MHz would require additional time and monetary resources to acquire and deploy 700 MHz LTE radios.

For the foregoing reasons, AT&T urges the Commission to grant permission to use PSD-based power measurements for its Cellular systems. Just as the Commission concluded in granting AT&T's waiver to operate using the PSD model in Florida, Vermont, and Missouri, a waiver for AT&T's Kentucky and Tennessee markets would strike an appropriate balance in the public interest, enable AT&T to make more effective use of spectrum by deploying LTE at Cellular stations, and provide enhanced product offerings to consumers, while also protecting public safety licensees and neighboring Cellular licensees from increased risk of harmful interference.[26]

III. CONCLUSION

For the reasons discussed above, AT&T respectfully requests that the Commission waive section 22.913 of the rules to permit AT&T's Cellular base stations in the Kentucky and Tennessee markets described herein to operate at 250 W/MHz in non-rural areas and 500 W/MHz in rural areas.

December 1, 2015

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[26] Florida Waiver, 29 FCC Rcd at 11643-44; Vermont Waiver, 29 FCC Rcd at 11637; Missouri Waiver at ¶25.

Appendix A

License[27]	CMA	Block	State	Rural Counties	Non-Rural Counties
KNKA576	209	B	KY/TN	-	Montgomery Christian
KNKA672	293	A	KY	-	Daviess
KNKN666	447	A	KY	Barren Wayne Adair Hart McCreary Russell Monroe Clinton Metcalfe Cumberland	-
KNKN673	453	A	KY	Whitley Knox Harlan Bell Clay Leslie	-
KNKN674	444	A	KY	Hopkins Union Trigg Webster Caldwell Livingston Crittenden Lyon	-
KNKN841	452	A	KY	Perry Letcher Knott Estill Breathitt Jackson Powell Lee Wolfe Owsley	-
KNKN861	451	A	KY	Pike	-

[27] This waiver should apply to all base stations providing service in the CGSA for each license, including minor extensions into CMAs and counties adjacent to those listed in this table.

				Floyd Johnson Lawrence Morgan Magoffin Martin Elliott	
KNKN964	448	B	KY	Lincoln Garrard Casey	Madison Boyle
KNKN965	448	B	KY	Laurel Pulaski	Rockcastle

Appendix B

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Date: **November 20, 2014**

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Subject: **A Further Comparison of the Impacts on Public Safety Receivers from the Various Wireless Technologies used in AT&T's Migration from Narrowband GSM to Broadband LTE in the 850 MHz CMRS Cellular Band in Kentucky Markets**

Abstract

The FCC Rules for the 850 MHz band were designed to accommodate first generation AMPS (Advanced Mobile Phone System) analog cellular service. Over the years, carriers deployed digital services in the 850 MHz bands, and eventually sunset analog services. Carriers currently use the 850 MHz band for technologies that support mobile broadband, such as UMTS. As the industry moves toward fourth generation LTE (Long Term Evolution) technology coupled with the use of MIMO (Multiple Input Multiple Output) techniques for spectral efficiency improvements, it is appropriate to consider whether the rules for this band relating to power measurement, which were adapted for technology deployed almost 30 years ago, should be revised to accommodate LTE. In band plans adopted more recently to accommodate mobile broadband deployment, the Commission has adopted a Power Spectral Density approach. This paper presents the results of a further study that considers whether making such a change to the 850 MHz rules to accommodate contemporary commercial mobile broadband deployments would increase the likelihood of interference to adjacent users of Public Safety bands in a Kentucky market.

The study addressed the interference impacts on Public Safety receivers under five different cases that are representative of AT&T's past, present, and future network comprising GSM, UMTS and LTE systems in various configurations in the cellular band. Results of this "real world" study again leads AT&T to conclude that a power limit based on a Power Spectral Density measure will not increase the possibility of harmful interference to adjacent bands and would maintain the "status quo" with respect to the potential impact on users of adjacent spectrum, such as the Public Safety Radio Service. The "real world" study results also supported a Power Spectral Density limit of 250 Watts/MHz in non-rural areas and 500 Watts/MHz in rural areas. As a result of this study, AT&T will file a petition at the FCC proposing to supplement the current per-emission ERP limits for cellular base stations with ones restated to include power spectral density limits.

1. Introduction

The FCC Rules for the 850 MHz band were designed to accommodate first generation AMPS (Advanced Mobile Phone System) analog cellular service. Over the years, carriers deployed digital services in the 850 bands, and eventually sunset analog services. Carriers currently use the 850 MHz band for technologies that support mobile broadband, such as UMTS (Universal Mobile Telecommunications System). As carriers migrate their wireless networks to fourth generation (4G) LTE (Long Term Evolution) technology and use MIMO (Multiple Input Multiple Output) techniques for spectral efficiency improvements, the FCC Rules governing the radiated power of transmitters in the Cellular Radiotelephone Service have come into question. MIMO uses multiple antennas or multiple antenna elements at both the transmitter and receiver to create multiple distinct spatial channels between the transmitter and the receiver using the same radio channel. AT&T plans to use 2x2 MIMO in its 850 MHz LTE deployments. 2x2 MIMO uses two transmitters operating on the same carrier channel but carrying two different information streams to create two separate spatial channels. Since two spatial channels are created using a single radio carrier, spectral efficiency is increased. The current FCC Rule governing radiated power in the Cellular Radiotelephone Service (Section 22.913) states - *the effective radiated power of base transmitters and cellular repeaters must not exceed 500 watts*. Since this power limit was enacted prior to the development and use of MIMO techniques, it was generally understood that a single transmitter used a single carrier frequency and the power requirement was related to this carrier frequency. A 2x2 MIMO deployment, which employs a single carrier channel on two transmitters, must split the maximum radiated power given in the FCC Rules between the two MIMO transmitters. This power split reduces the service coverage area of the transmitters operating in the MIMO mode compared to that of a single transmitter deployment.

In 2004, recognizing the problem posed by the then current power limitation rules, CTIA offered a technologically neutral proposal to modify base station power limits for PCS licensees. Subsequently, the Commission expanded this proposal to include not only PCS, but also cellular radio service and other service bands. In 2008, following comments on the proposal, the FCC revised the radiated power rules for certain services, notably PCS and AWS, but declined to extend the revision to cellular radio service because the frequencies immediately adjacent to the 850 MHz cellular band were undergoing significant restructuring and "until [it could] better assess the impact of additional power limit changes" on the possibility of harmful interference to adjacent bands. Since then, re-banding of services adjacent to the cellular band is almost complete and there has been adequate time to understand the interference concerns, if any, due to the adoption of Power Spectral Density (PSD) rules in PCS and AWS bands. Such a PSD limit would allow the use of MIMO techniques in the 850 MHz band without requiring a reduction in the service coverage area, and would be more consistent with FCC broadband power limit rules in other bands. A PSD limit specifies the amount of power that is distributed with frequency and, in the case of the cellular radiotelephone service, it is the amount of power distributed over a radio channel. If the maximum radiated power in a 5 MHz channel is 1500 watts, the PSD would be 300 watts/MHz (1500 watts/5 MHz).

Believing that a PSD measure should now be adopted for the cellular bands, AT&T conducted a technology interference comparison analysis of its third generation (3G) UMTS and 4G LTE technologies to show that a power limit based on a Power Spectral Density measure will not increase the possibility of harmful interference to adjacent bands and would also maintain the "status quo" with respect to the potential impact on users of adjacent spectrum, such as the Public Safety Radio Service. The results of the technology interference comparison supported AT&T's belief. The study results also supported a Power Spectral Density limit greater than 100 Watts/MHz.

To further bolster AT&T's belief that a power limit based on a Power Spectral Density measure will not increase the possibility of harmful interference to adjacent bands, AT&T completed a second "real world" study which determined the interference impacts on users of adjacent spectrum as a result of its technology migration through the years – from second generation (2G) GSM (Global Systems for Mobile Communications) to 4G LTE with MIMO. AT&T's technology migration study commences with the deployment of 2G GSM technology employing a tri-sectored frequency reuse pattern of N=12 that typically allowed on average up to five GSM carriers per sector. With the migration to broadband 3G UMTS technology, some GSM carriers were replaced with a single UMTS carrier. A typical sector in an initial 3G network would include one UMTS and three GSM carriers. As broadband demand increased, the spectrum for a second UMTS carrier was again re-farmed from existing GSM carriers. A typical congested metro market deploys two UMTS carriers along with two GSM carriers per sector. As the data traffic demand increased, a migration to 4G LTE in the cellular bands will be necessary. LTE deployments will precede by replacing one of the UMTS carriers with a 5 MHz LTE carrier employing 2X2 MIMO. Initial deployments of LTE will include a 5 MHz UMTS carrier, a 5 MHz LTE carrier, and two GSM carriers in the cellular band. The final migration will be to replace the remaining UMTS and GSM carriers and to upgrade the 5 MHz LTE carrier to a 10 MHz LTE carrier. The LTE deployments will be with two transmitters per carrier/sector as compared to a single transmitter per carrier/sector with UMTS. This paper documents the final results of that study.

1. Modeling the Interference Environment

Modeling the interference environment consisted of the following five steps:

1. Model the interference path
2. Determine the transmitter and receiver characteristics
3. Model the interference mechanisms
4. Calculate the interference levels and determine their impacts

1.1 Modeling the Interference Path

Since the interference network environment is that of a standard cellular architecture, two propagation loss models were used to calculate path loss. These two propagation loss models were the HATA loss models and the modified Friis Transmission Loss model. The HATA models are the most widely used radio frequency propagation models for predicting the behavior of cellular transmissions. Since the HATA models are accurate for link distances between 1 and

20 kilometers, another model was needed for paths closer to the cell site. The Friis Transmission Loss model is ideal for paths between two isotropic antennas in free space (Line-of-Sight) and can be modified for paths other than free space (Non-Line-of-Sight). All loss models were incorporated into the Friis Transmission Equation which relates received power, transmit power, antenna gains and path loss in order to calculate interference levels. For line-of-sight paths a propagation constant of 2 was used and for non-line-of-sight paths, a propagation constant of 2.4 was used. Cellular antenna heights for non-rural areas of Kentucky used the average antenna height in the Kentucky market - 30 meters. For rural areas of Kentucky where antenna heights are generally higher, antenna heights of 47 and 92 meters were used. The average antenna height for the Kentucky markets in this study was 73 meters.

1.2 Determining the Transmitter and Receiver Characteristics

The transmitter and receiver characteristics were:

- Maximum transmit power
- Base station antenna gains and discrimination
- Transmission line loss
- Transmitter sideband emission levels
- Public Safety receiver noise floor
- Minimum mobile Adjacent Channel Rejection Ratio
- Minimum portable Adjacent Channel Rejection Ratio
- Public Safety mobile antenna gain: From an Internet site on Public Safety equipment
- Public Safety portable antenna gain: From an Internet site on Public Safety equipment
- Public Safety Receiver Overload level
- Third Order Intercept Point calculation: From *Motorola paper by Bruce Oberlies – "Public Safety Interference Environment – Raising Receiver Performance Requirements"*
- Third Order Interference Level calculation: From Aeroflex Application Note on Intermodulation Distortion on the website www.aeroflex.com.

1.3 Modeling the Interference Mechanism

The three near/far interference mechanisms common in Public Safety interference environments were modeled in the following manner:

1. Intermodulation – The receive interference level at the input to the Public Safety receiver's front end was calculated using the appropriate Friis Transmission Equation. The study assumed that the GSM channels were transmitting at 500 Watts, UMTS channels were transmitting at 500 Watts, and LTE at 500 Watts/transmitter-antenna for a 5 MHz channel and 1000 Watts/transmitter-antenna for a 10 MHz channel. Since Effective Radiated Power level is the power level radiating from the base station's antenna, no transmission line loss or base station antenna gain was included in this calculation. It was assumed that these levels were the levels of the two interfering signals creating the intermodulation product. The third order intercept point was calculated using the formula in the Motorola paper and this value was used in the Aeroflex equation with

the interference levels calculated from the Friis Transmission Equation to obtain the level of the third order product in the receiver.

2. Transmitter Sideband Emissions - The transmitter sideband emission level at the input to the Public Safety receiver's front end was calculated using the appropriate Friis Transmission Equation. The sideband transmit power level at the output of the transmitter used in this equation was the measured spurious emissions level given by the manufacturer. For this calculation in the Friis Transmission Equation, transmission line loss and base station antenna gain were included.

3. Receiver Overload - The received interference level at the input to the Public Safety receiver's front end was calculated using the appropriate Friis Transmission Equation. The cellular base station transmit power level used in this equation was the maximum Effective Radiated Power level specified in the FCC Rules for Cellular services in the 850 MHz cellular band for 2G and 3G technologies (GSM channels were transmitting at 500 Watts, UMTS channels were transmitting at 500 Watts, and LTE at 500 Watts/transmitter-antenna for a 5 MHz channel and 1000 Watts/transmitter-antenna for a 10 MHz channel). Since Effective Radiated Power level is the power level radiating from the base station's antenna, no transmission line loss or base station antenna gain was included in this calculation.

1.4 Interference Levels and Their Impacts

An Excel spreadsheet was developed to make the above mentioned calculations and determine the impacts of the various interference mechanisms. For the intermodulation interference calculation and the transmitter sideband emission interference calculation, the criteria used to determine impact was a rise in the receiver's noise floor. For Receiver Overload interference calculations, the criteria used to determine impacts was that any interfering level that was less than the specified overload point of the receiver is an acceptable interfering level. For this study only the relative levels of the interference environments are compared. Only in situations where a technology's interference environment level is no worse than the existing technology's interference environment level can the interference level be deemed acceptable (Status Quo).

The study addresses the interference impacts on Public Safety receivers under five different cases that are representative of AT&T's past, present, and future network comprising GSM, UMTS and LTE systems in various configurations in the cellular band. Case one represents an initial 2G GSM deployment of five GSM carriers. Case two addresses the migration to one UMTS carrier and three GSM carriers. Case three represents the migration to two UMTS carriers along with two GSM carriers per sector. Case four represents a migration to 4G LTE with a 5 MHz UMTS carrier, a 5 MHz LTE carrier with MIMO, and two GSM carriers. The final migration, Case five, will be to a single 10 MHz LTE carrier with MIMO.

2. Study Results

With a single GSM channel's transmit power level set to 500 Watts, a single UMTS channel set to 500 Watts, and a LTE channel set to 500 Watts/transmitter-antenna for a 5 MHz channel and

1000 Watts/transmitter-antenna for a 10 MHz channel, the results of the Excel spreadsheet calculations of interference into Public Safety receivers with bandwidths of 25 and 12.5 KHz from the five migration cases for non-rural and rural environments are shown in Tables 1 through 12. Bracketed numbers in the overload tables are received overload interference levels in dBm.

2.1 Intermodulation Interference Impacts

	PS RECEIVER BANDWIDTH = 25 KHz				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	9.4362	9.4362	9.4362	9.4362	0.0173
200	6.4700	6.4700	6.4700	6.4700	0.0076
>1000	0.0482	0.0482	0.0482	0.0482	0.0000

	PS RECEIVER BANDWIDTH = 12.5 KHz				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	18.0114	18.0114	18.0114	18.0114	0.1363
200	14.5468	14.5468	14.5468	14.5468	0.0607
>1000	0.3717	0.3717	0.3717	0.3717	0.0002

TABLE 1. Non-Rural Mobile Intermodulation Impacts

	PS RECEIVER BANDWIDTH = 25 KHz				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0043	0.0043	0.0043	0.0043	0.0000
200	0.0019	0.0019	0.0019	0.0019	0.0000
>1000	0.0482	0.0482	0.0482	0.0482	0.0000

	PS RECEIVER BANDWIDTH = 12.5 KHz				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0339	0.0339	0.0339	0.0339	0.0000
200	0.0104	0.0104	0.0104	0.0104	0.0000
>1000	0.0000	0.0000	0.0000	0.0000	0.0000

TABLE 2. Non-Rural Portable Intermodulation Impacts

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 47 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.5766	0.5766	0.5766	0.5766	0.0000
200	8.9790	8.9790	8.9790	8.9790	0.0019
>1000	1.0994	1.0994	1.0994	1.0994	0.0001

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 47 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	3.2957	3.2957	3.2957	3.2957	0.0003
200	17.5004	17.5004	17.5004	17.5004	0.0076
>1000	5.1913	5.1913	5.1913	5.1913	0.0006

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 92 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0000	0.0000	0.0000	0.0000	0.0000
200	0.0076	0.0076	0.0076	0.0076	0.0000
>1000	3.3683	3.3683	3.3683	3.3683	0.0003

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 92 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0003	0.0003	0.0003	0.0003	0.0000
200	0.0601	0.0601	0.0601	0.0601	0.0000
>1000	10.1597	10.1597	10.1597	10.1597	0.0026

TABLE 3. Rural Mobile Intermodulation Impacts